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Abstract

We estimate alternative price-to-rent ratios in the Spanish housing market by considering different stochastic discount factors in present value models similar to those used in the financial literature but where the higher rigidity that characterises this market is taken into account. We identify three robust across-model regularities: i) the increase in the price-to-rent ratio since the late nineties helped at first to restore equilibrium, ii) further increases in house prices raised the ratio between 24% and 32% above equilibrium by 2004, although iii) at that time the ratio was only around 2% above its short-term adjustment path towards a (new) long-run equilibrium.

JEL: G12, R21, R31.

Keywords: Housing, price-to-rent ratio, overvaluation.

1 Introduction

In the last few years, the analysis of the housing market has become an important input for the general assessment of the prospects of a number of industrialised economies. This is the case, among others, of the USA, the UK, Australia, Ireland and Spain, where house prices have been growing at very high rates, thereby providing a significant support to economic activity, through wealth effects. At the same time, the concern has been raised that real estate markets in some of those countries could be subject to speculative waves that could eventually trigger sharp corrections and generate macroeconomic and financial instability.

A case in point is Spain where real state prices increased between 1998 and 2005 by a cumulative amount of more than 150% in nominal terms, a figure similar to that in the UK and considerably higher than those observed in any other continental European country or the US. This house price boom has gone hand in hand with important structural changes in the Spanish economy which have heavily affected variables like income, interest rates and demographic factors, usually considered among the set of economic fundamentals which explain the behaviour of house prices. A key issue in this regard is, therefore, to assess whether the current level of prices is sustainable.

The standard approach to study the possible existence of misalignments in housing markets consists of checking the compatibility between observed prices and fundamentals using an estimated equilibrium model for house prices. Often, the estimated model follows the *macroeconomic approach* suggested by Poterba (1984 and 1991) under which equilibrium prices are a function of interest rates, income and supply side variables [see e.g. IMF (2004)]. Recently, however, a number of authors have preferred exploiting the equilibrium relationship between house prices and rents, as suggested originally by Case and Shiller (1988) and Clayton (1996). This *financial approach* permits a more parsimonious specification of equilibrium prices as most factors affecting house prices exert their influence through their impact on the net demand for accommodation services and are therefore captured by rents.

Most available studies that employ the financial approach [see e.g. OECD (2005), Himmleberg et al. (2005) and ECB (2006)] tend to focus on static relations between house prices, rents and interest rates that are only valid under constant expected house price growth. Moreover, they do not consider any possible discrepancy between observed prices and fundamentals due to frictions that could prevent the immediate adjustment in this market of supply and demand. As a consequence, they tend to interpret any significant gap between the price data and the model prediction as a symptom of speculative behaviour which not need be so. Finally, models typically ignore the possible effects of taxes on the equilibrium relationship between house prices and rents.

In a previous paper [Ayuso and Restoy (2006)] we resolved partially those deficiencies by employing a relatively general intertemporal asset pricing model to estimate the dynamic equilibrium relationship between house prices and rents. We also took into account possible transaction costs and regulations that hinder the immediate adjustment of house prices and rents to changing conditions by specifying a dynamic relationship that permits transitory but persistent deviations from equilibrium. Estimations showed that in 2003

Spanish house prices were significantly above their long-term fundamentals although they seemed in line with the estimated adjustment path towards equilibrium.[1]

The approach followed in Ayuso and Restoy (2006) permits a time-varying path for the price-to-rent ratio to be estimated by exploiting first-order conditions of a representative agent economy. In that setting the stochastic discount factor that agents apply to future rents is a function of consumption growth as this determines the intertemporal marginal rate of substitution. This makes it possible to fully determine equilibrium prices as a function of macroeconomic determinants. But this is obviously done at the cost of assuming specific preferences and imposing potentially restrictive equilibrium conditions that could be generally invalid, for example under financing or liquidity constraints. It is therefore legitimate to ask whether results could be different under less stringent modelling assumptions. In particular, it is relevant to analyse the empirical implications of dropping the conditions relating asset returns to the marginal rate of substitution.

In this paper we build on the financial approach to determining equilibrium house prices. In particular we estimate alternative present value models with a number of stochastic discount factors which are consistent with different asset pricing set-ups. Our objective is therefore to contribute to the assessment of the sustainability of current prices by testing whether results obtained from a financial asset pricing standpoint are dependent on the choice of a specific discount factor. In particular, we are interested in identifying those results that prove to be sufficiently robust to such a choice. Moreover, we provide some evidence on the robustness of our results to tax considerations.

According to our results, there are some findings that do not seem to be model-dependent at all. More concretely, changing the discount factor does not affect our conclusions that the increase in the price-to-rent ratio witnessed since the late 1990s contributed at first to restoring an equilibrium situation, although it ended up leading the ratio beyond its long-run level. The magnitude of the corresponding gap depends, however, on the model chosen, spanning a range between 24% and 32%. This gap, however, seems to be only a few percentage points above the one we should expect when the rigidities in this market and its consequences in terms of a smooth short-term adjustment path between long-run equilibrium levels are taken into account.

The paper is structured as follows. In Section 2 we introduce the intertemporal asset pricing set-up from which the alternative present value models are derived. In Section 3, we explain our empirical strategy, comment on the database used, and present the main empirical results. Lastly, in Section 4 we outline the main conclusions of the paper.

1. Additional evidence of overvaluation –based on simpler methodologies– can be found in Balmaseda et al. (2002), Martínez-Pagés and Maza (2003), García Montalvo (2003), OECD (2005) and ECB (2006).

2 The set-up

Following Campbell and Shiller (1988), we can approximate the (net) real return of any asset (say a house) between *t* and *t+1*, r_{t+1}, as

$$r_{t+1} \approx d_{t+1} + q_{t+1} - \frac{1}{\delta} q_t - k \ , \tag{1}$$

where d_{t+1} is the real growth rate of dividends (rents) between *t* and *t+1*, q is the (log) asset price-dividend ratio and δ and k are linearisation constants, the former playing the role of a discount rate as will be explained later on.

We will now assume that the risk class of housing (understood as the equilibrium risk premium over any other asset) is constant.[2] For any portfolio *m,* let us then define π_m as

$$\pi_m \equiv E_t \ r_{t+1} - E_t \ r_{m,t+1} \, , \tag{2}$$

where r_m stands for the (log) real return on the portfolio *m*.

Solving (1) forward for q_t, assuming that bubbles are unfeasible, taking expectations on both sides of the resulting expression, and using (2) yields

$$q_t^* = -\left(k \ + \pi_m\right) \frac{\delta}{1-\delta} + E_t \sum_{s=1}^{\infty} \delta^s \left[d_{t+s} - r_{m,t+s}\right]. \tag{3}$$

Therefore, we can approximate (up to a constant) the price-to-rent ratio as the present discounted sum of future expected rents minus the present discounted sum of future expected returns on any asset or portfolio of assets. The latter plays the role of the stochastic discount factor that should be applied to future payoffs.

As a particular case, we could consider as the reference portfolio a claim on future consumption growth, which in a standard representative agent economy will be equal in equilibrium to the economy's aggregate (wealth) portfolio. If intertemporal preferences are assumed to be of a generalised isoelastic form [see Epstein and Zin (1989), and Weil (1990)], Restoy and Weil (1998) show that the equilibrium relationship between the return on the wealth portfolio (r_w) and consumption growth (x) can be approximated by the simple linear expression

$$E_t \left(r_{w,t+1}\right) = u + \rho \ E_t \ x_{t+1} \, ,$$

2. This is obviously the case in standard asset pricing models where returns are homoscedastic. Note that the expected capital gain on housing does not need to be constant as typically assumed in the standard empirical specifications of the relationship between house prices and rents.

where ρ is inverse of the elasticity of intertemporal substitution (which under GIP preferences may not be equal to the relative risk aversion coefficient) and u is a constant. Moreover, Ayuso and Restoy (2006) show how this model could be extended to the case in which preferences are non-separable between good consumption and housing services and derive equilibrium house prices in that set-up. In particular, they provide the following equation for the equilibrium price-to-rent ratio in the housing market:

$$q_t^* = h + \tau\, E_t \sum_{s=1}^{\infty} \delta^s\, d_{t+s} - \rho\, E_t \sum_{s=1}^{\infty} \delta^s\, x_{t+s} \tag{4}$$

where $h = \left(-k + \pi_w + u\right)\dfrac{\delta}{1-\delta}$ and τ is a constant that depends on both the elasticity of intertemporal substitution and the elasticity of substitution between housing and consumption.

Therefore, in this setting the price-rent ratio is approximated by a linear function of the discounted sum of future expected growth rates of rents and the discounted sum of future expected growth of the consumption aggregator. Not surprisingly, the higher the future expected rents the higher the current price of houses. Also, the higher the future expected consumption aggregator, and the higher the inverse of the elasticity of intertemporal substitution, then the higher the equilibrium discount rate of future rents and, therefore, the lower the current asset price. It is worth noting that when $\rho = 0$, equation (4) collapses to the standard expression where prices are a function of future expected payoffs discounted at a constant rate δ.

Both expressions (3) and (4) are suitable for the empirical determination of the equilibrium house-to-price ratio. The latter permits a more genuine equilibrium analysis as housing prices are solely determined by rents and macroeconomic developments. It does however rely on a specific parameterisation and on relatively demanding intertemporal equilibrium conditions of a representative agent. The former only requires assuming that there are no arbitrage opportunities and that the risk premia of all assets are stable over time.

Therefore, it seems justified to explore the extent to which the estimation of the equilibrium price-to-rent ratio depends on the asset pricing model employed and, in particular, to investigate whether estimates vary with the stochastic discount factor applied to future expected rents. As this seems to be in essence an empirical question, we propose computing equilibrium prices according to both equations (3) and (4). The former will also admit several versions depending on the definition chosen for the reference portfolio *m*. We will then be able to assess the differences found and to identify those results which are robust to the choice of a particular discount factor. Also, before estimating long-run equilibria we have to enlarge our equations in order to capture the short-term dynamics arising from extant rigidities in this market.

3 Empirical analysis

3.1 Empirical strategy

In section 2 we derived equilibrium relationships for the (log) ratio of house prices to rents. Let the corresponding *observed value* of the ratio be denoted by q_t to distinguish it from the long-run *equilibrium* ratio q_t^*, which is the value consistent with expressions (3) and (4). Thus,

$$q_t = q_t^* + g_t \tag{5}$$

where g_t is the gap, at *t*, between the observed ratio and its equilibrium value. The rationale for this gap can be found in both the rigidities that affect the adjustment of quantities in the property market as well as the slow adjustment of average prices in the rental markets.

As building a new house takes a long time, the responses by supply to unexpected demand shocks are very likely to show a high degree of sluggishness and prices would tend to overreact in the short run to such shocks. DiPasquale and Wheaton (1994), Kenny (1999) or Genesove and Mayer (2001) have documented the relevance of supply adjustment costs to explain house price behaviour. Ortalo-Magné and Rady (2001) also show how house prices may overreact in the short run to income shocks because of the interaction between young credit-constrained households and old non-constrained ones.

By contrast computed rents tend to vary much less. As will be explained later, we compute rental prices from the corresponding domestic CPI shelter components. However, as the average maturity of rental contracts is typically well above one quarter, it will take some time for changes in the equilibrium value of rents to be fully incorporated into the corresponding CPI component. This lag will be all the greater the longer the average maturity of rental contracts. Thus, even if there are no unexpected demand shocks, the price-dividend ratio will converge to its equilibrium with some stickiness.

Nevertheless, obtaining an explicit theory-based expression for g_t is beyond the scope of this paper. We rather follow Ayuso and Restoy (2006) and adopt a purely empirical approach. In particular, we characterise g_t as follows

$$\Phi(L) g_t = \beta\, w_t + \varepsilon_t, \tag{6}$$

where $\Phi(L)$ is a standard polynomial of order *p* in the lag operator *L* that meets the usual stationarity conditions, w_t is a zero-mean stationary variable capturing demand pressures (so that β is expected to be positive) and ε_t is standard iid white noise. Note that according to expression (6), prices can deviate from equilibrium only transitorily, although deviations may show some degree of persistence. In this respect, the slow adjustment of q_t towards its long-run equilibrium level after a shock resembles the adjustment pattern that characterises the behaviour of rigid variables in standard overshooting models.

Combining (4) and (6) we obtain:

$$q_t = g(1-\sum_{i=1}^{p} \phi_i) + \sum_{i=1}^{p} \phi_i q_{t-1} + \tau\, E_t \sum_{s=1}^{\infty} \delta^s\, d_{t+s} - \rho\, E_t \sum_{s=1}^{\infty} \delta^s\, x_{t+s}$$
$$-\tau \sum_{i=1}^{p} \phi_i\, E_{t-1} \sum_{s=1}^{\infty} \delta^s\, d_{t-1+s} + \rho \sum_{i=1}^{p} \phi_i E_{t-1} \sum_{s=1}^{\infty} \delta^s\, x_{t-1+s} + \beta\, w_t + \varepsilon_{1t} \tag{7}$$

where $g = k + \pi_m$.

Likewise, combining (3) and (6) yields:

$$q_t = h(1-\sum_{i=1}^{p} \phi_i) + \sum_{i=1}^{p} \phi_i q_{t-1} + E_t \sum_{s=1}^{\infty} \delta^s\, d_{t+s} - E_t \sum_{s=1}^{\infty} \delta^s\, r_{m,t+s}$$
$$-\sum_{i=1}^{p} \phi_i\, E_{t-1} \sum_{s=1}^{\infty} \delta^s\, d_{t-1+s} + \sum_{i=1}^{p} \phi_i E_{t-1} \sum_{s=1}^{\infty} \delta^s\, r_{m,t-1+s} + \beta\, w_t + \varepsilon_{2t} \tag{8}$$

In order to generate the regressors that incorporate consumers' expectations in equations (7) and (8) we make use of the VAR approach suggested by Campbell (1993) as adapted by Rodríguez et al. (2002). This VAR approach permits a very general interaction between house prices and rents (and the remaining variables) as we do not impose ex-ante any direction of causality between one and the other.

Thus, for each discount factor we define $y_t \equiv [y1_t \mid y2_t]$ as a k-vector where $y1_t$ is a vector of dimension 2 including d_t and the discount factor and $y2_t$ is a (k-2) vector incorporating other variables which help predict $y1_t$. As shown in Campbell and Shiller (1988), we can re-write any VAR for y_t as a VAR (1) model for a pp-dimensional variable z_t which includes y_t and *pp-1* lags of the variables in this vector. Denoting this transformed VAR(1) by

$$z_{t+1} = a + Az_t + \xi_{t+1} \tag{9}$$

we can easily compute the expectations terms in (7)-(8) as

$$E_t \sum_{s=1}^{\infty} \delta^s d_{t+s} = i2' \left[\delta\, (I-A)^{-1} \left[\frac{1}{1-\delta}\; I - A\, (I-\delta\, A)^{-1} \right] a + \delta\, A\, (I-\delta\, A)^{-1} z_t \right] \tag{10}$$

and

$$E_t \sum_{s=1}^{\infty} \delta^s j_{t+s} = i3' \left[\delta\, (I-A)^{-1} \left[\frac{1}{1-\delta}\; I - A\, (I-\delta\, A)^{-1} \right] a + \delta\, A\, (I-\delta\, A)^{-1} z_t \right] \tag{11}$$

where *j* stands for the discount factor, *i2* (*i3*) is a *k* vector made up of zeros except for the component corresponding to the position of d_t (j_t) in z_t, which is equal to 1.

In the empirical application, we follow Campbell (1993) and replace δ by the sample average of the (log) consumption-wealth ratio.[3]

As to the estimation methodology, it is worth noting that both the expectations variables at t and w_t might be correlated with the error term. Therefore, we estimate (7)-(8) by GMM and instrument these variables.

3.2 Data

We use quarterly data spanning the longest available period: 1987Q1-2004Q4. Although this is a relatively short period, it is worth noting that it covers the end of the mid-eighties boom in the Spanish housing market, the subsequent correction and the new expansionary stage that started in the late nineties and is still going on. Thus, it seems to include a complete cycle in the market.

As usual in the literature, rents are computed from the corresponding component of the consumer price index.[4] As to house prices, we have used the average price per square metre of all dwellings released formerly by the Spanish *Ministerio de Fomento* and currently by the *Ministerio de la Vivienda*.

The return on the reference portfolio *m* in equation (8) has been proxied by three different empirical variables. As in most papers in the literature, we used first a broad stock index. In particular, we considered the return on the Ibex-35.[5] Then, we used a bond portfolio by considering the total return index released by the Banco de España, which measures the (monthly) total return on a theoretical portfolio made up of all outstanding bonds issued by the Spanish Treasury with a residual maturity longer than 1 year.[6] Finally, to include a proxy in which both stocks and bonds can play a role, we have also considered the change in households' financial wealth as a proxy for the return on Spanish households' portfolio. In this regard, it is worth noting that for quarterly data at least, it seems reasonable to expect price-change effects to dominate quantity movements in that portfolio.

As to the variables in $y2_t$ (i.e. the candidates to help predict rents and the different stochastic discount factors) we included (the adequate stationary transformations of) GDP, (net) financial and non-financial wealth, household consumption –execpt for the model where it is included in $y1_t$– and the 10-year interest rate. Finally, following Ayuso and Restoy (2006) we proxy transitory demand pressure –i.e. the vector w_t in equation (6)– by de-meaned and sign-changed changes in households' financial wealth (see Chart 1). Thus, an increase in w_t captures the (positive) transitory effect on housing demand of a transitory fall in the price of alternative financial assets.

---

3. We also considered an alternative calibration, also suggested in Campbell (1993), based on the estimate in Ayuso (1996) of the time-preference parameter θ in $V_t = \sum_{i=0}^{\infty} \vartheta^i E_t \; U(C_{t+i})$. He provides an estimate around 0.988, well in line with the results in Canova and Marrinan (1996). Changes were, however, qualitatively negligible.

4. See, for instance, Mankiw and Weil (1989) or Case and Shiller (1989 and 1990). For a critical view of this approach, see Clayton (1996).

5. We also tried the return on a world stock index (the MSCI World index) as well as a combination of returns on the domestic (until 1998Q4) and the world (since 1999Q1) stock exchanges. Both discount factors provided fairly similar results to those reported here.

6. For details on the index, see Banco de España (1991). It is also worth noting that non-government bonds have traditionally played a very minor role in Spanish households' portfolios.

All variables used in the empirical estimates have been deflated by the Spanish CPI index excluding shelter.

Table 1 shows some descriptive statistics for the main variables used in the analysis, while Chart 2 depicts the path of (deflated) house prices, (deflated) rents and the (ln) price-dividend ratio corresponding to housing investment. Real house prices display an upward trend throughout the available sample, the level reached in 2004 being three times higher than in 1987. Real rents, which also display an upward trend, have increased less (38%) and, as a consequence, the price-dividend ratio has grown very sharply over the sample period. Also worth noting are the wide fluctuations in house prices and therefore in the ratio.

3.3 Results

Regarding the first step of our empirical approach, Table 2 shows the main results of the estimation of the four different VARs focusing on the two equations of interest (namely, those for rents and the discount factor). The number of lags has been chosen according to the Akaike criteria, after testing that no residual correlation was left.

VARs tend to explain better the changes in real rents than in the discount factor, as is revealed by the different equation standard errors, which are in general reasonably small for the former (around 0.5%). For the latter, they range from 0.8% for consumption growth to 12% for the real return on the stock exchange index.

As to the second step, the main results of the GMM estimates are shown in Table 3. Here we present estimates for five specifications: i) the equilibrium "consumption" model –as in equation (7); ii) three versions of equation (8) corresponding to the three different definitions of the reference portfolio *m*; and iii) a simple constant discount factor model. As can be seen, all but the constant discount-factor model fit the data well. Moreover, they show Sargan tests well above 10% and residual standard errors that vary between 6% and 12%. On the contrary, the results for the constant discount factor model are much poorer. The Sargan test rejects the instrument set and there is clear evidence of residual autocorrelation, maybe caused by an overestimate of the parameter ϕ_1 which violates stationarity conditions. As this does not change when more lags in $\Phi(L)$ or alternative instrument sets are considered, we interpret the results in column 5 as evidence in favour of time-varying discount factors.

Focusing therefore on the results for equations (7) and (8) we find clear evidence of strong price inertia. While one lag is enough to properly characterise the dynamics of g_t, ϕ_1 is estimated at around 0.9. Also, β is found to be significant in the four models considered. Finally, it is worth noting that the point estimate for ρ implies an elasticity of intertemporal substitution around 0.1, well in line with the results in the available literature.[7]

In any case, it is important to note that we are not interested in econometrically discriminating among the stochastic discount factors considered. Our objective is rather to analyse the implications of choosing different reasonable discount factors with a view to identifying those results which are robust across models.

7. See, for instance, Campbell (1999).

To that end, we built both an estimated equilibrium price-dividend series and an estimated short-term adjustment path to equilibrium, where rigidities in the housing market are explicitly taken into account. Thus, while an observed ratio above the estimated equilibrium value would imply some overvaluation, an observed ratio above the adjusted one would mean that it is reverting to its equilibrium more quickly (if it is below equilibrium) or more slowly (if it is above equilibrium) than implied by the equation. Charts 3.1 to 3.4 show for each model three different series: the actual price-dividend series, the short-term adjustment path and the long-run equilibrium estimates.

As could be expected, there are differences among the estimates of the long-run equilibrium values, although they are much smaller regarding short-term adjustment paths. Charts 2.1 and 2.2 provide quite a similar picture. Charts 2.3 and 2.4 are also very similar to each other, although they differ notably from the previous ones. It is worth noting in this regard that in the first two charts the sensitiveness of the price-to-rent ratio to short-term shocks is higher and the shock effects are less persistent than in the other two models.

In any event, our focus has to be on identifying the commonly shared implications of the four charts. To do so, we build "average" long-run equilibrium and short-term adjustment paths as simple arithmetic averages of the results for each model and assess the uncertainty surrounding this "average" behaviour by comparing them to the maximum and minimum model estimates in each year, which provide us with a sort of "plausibility" range.

Chart 4 shows the average, minimum and maximum estimated equilibrium values for the price-to-rent ratio. As can be seen, the average equilibrium ratio displays some upward trend since the mid-1990s, which is later followed by a rapid increase in the observed ratio. The latter, moreover, tends at first to restore equilibrium in the market after the sharp decrease in the price-to-rent ratio that followed the end of the previous boom in the early nineties. The increase in the observed ratio, however, ends up going beyond required to restore equilibrium and as a result, the situation in 2004 is one of overvaluation, which, on average, amounts to around 29%. It is worth remembering at this point that our approach does not allow us to discriminate between house price overvaluation and rent undervaluation.

The uncertainty in the estimated average behaviour is, as could be expected, quite significant. Notably, however, despite model diversity, the result that the increase in the ratio since 1998 contributed to restore equilibrium is fairly robust. In the same vein, all models coincide in pointing towards overvaluation at the end of the sample period. More concretely, they span a range from 24% to 32% for overvaluation.

Chart 5 replicates the exercise in Chart 4 for the estimated short-term adjustment path. As commented above, the differences are much less significant in this case. Thus all models allow it to be concluded that during the current boom in the housing market, the price-dividend ratio has moved well in line with its historical short-term adjustment pattern. At the very end of the sample period the observed ratio is only around 2% above the short-term estimated path.

3.4 Taxes

Before concluding, it should be mentioned that both in the theoretical model and in its empirical application we have not considered taxes. The detailed analysis of the impact of the tax-subsidy system on rents and house prices is a complex task that falls outside the scope of the paper. In particular, it is important to note that the heterogeneous tax treatment of individual agents makes it very difficult to identify the “marginal” agent affecting asset pricing conditions.

Nevertheless, we can make use of the results reported in a recent paper by García-Vaquero and Martínez-Pagés (2005) on taxes and the housing market in Spain to investigate the potential effects of ignoring taxes on our overvaluation estimates.

Thus, note first that if we could identify the marginal agent and its tax treatment, we would be able to obtain a tax modified version of equation (3) for it. More concretely, we would have to take into account that the dividends obtained from the asset (house) in each period will include rents plus subsidies obtained minus taxes paid. The net flow of taxes and subsidies can always be expressed as a percentage of rents and the corresponding ratio could be seen as a sort of “net tax rate” on rents. Thus, if we still use D_t for real rents – d_t being its (log) growth rate– and represent that net tax rate as ψ_t it is easy to see that:

$$q_t \equiv \ln \frac{P_t}{D_t(1-\psi_t)} \approx q_t^b + \psi_t \tag{12}$$

where q_t^b is the price-to-rent ratio before taxes.

If we make the assumption that changes in the net tax rate are unpredictable for the marginal agent, it follows directly from equation (12) that nothing changes on the right-hand sides of equations (3) and (4), as $E_t \sum_{s=1}^{\infty} \delta^s \Delta\psi_{t+s} = 0$. Therefore, combining (5) and (12) to obtain an empirically workable equation for the observable before-tax price-to-rent ratio we have:

$$q_t^b = q_t^* + g_t - \psi_t \tag{13}$$

From the results in García-Vaquero and Martínez (2005) it is possible to obtain a proxy for ψ_t for different classes of households. More specifically, they obtain (annual) estimates of the wedge introduced by all relevant taxes and subsidies affecting housing demand (VAT, property tax, income tax relief, etc.) in the user costs of houses for different households according to their income, their age, and their property tenure (landlord, tenant, first-home owner occupier, second-home owner). Since user costs have to equal rents at (before tax) equilibrium, we can use the ratio of the estimated wedge to the user costs before taxes as a proxy for ψ_t. More precisely, if we allow for some measurement error we can write $\psi_t = \lambda_0 + \lambda\zeta_t + \upsilon_t$, where ζ_t is the estimated ratio of the tax wedge to the user costs before taxes and υ_t is iid white noise uncorrelated to the shock in equation (6).[8] After some algebra, we can obtain modified versions of (7) and (8) that explicitly include taxes:

8. We thank the authors for providing us with these series. See the quoted reference for more details on how the representative agents are chosen and the tax wedges are computed.

$$
\begin{aligned}
q_t &= n\ (1-\sum_{i=1}^{p}\ \phi_i) + \sum_{i=1}^{p}\ \phi_i q_{t-1} + \tau\ E_t\ \sum_{s=1}^{\infty}\delta^s\ d_{t+s} - \rho\ E_t\ \ \sum_{s=1}^{\infty}\delta^s\ x_{t+s} \\
&- \tau \sum_{i=1}^{p}\ \phi_i\ E_{t-1}\ \sum_{s=1}^{\infty}\delta^s\ d_{t-1+s} + \rho \sum_{i=1}^{p}\ \phi_i E_{t-1}\ \ \sum_{s=1}^{\infty}\delta^s\ x_{t-1+s}\ + \beta\ w_t - \\
&\lambda\ \zeta_t + \lambda \sum_{i=1}^{p}\ \phi_i \zeta_{t-i} + \varepsilon_{3t}
\end{aligned} \tag{14}
$$

$$
\begin{aligned}
q_t &= n'\ (1-\sum_{i=1}^{p}\ \phi_i) + \sum_{i=1}^{p}\ \phi_i q_{t-1} + E_t\ \sum_{s=1}^{\infty}\delta^s\ d_{t+s} -\ E_t\ \ \sum_{s=1}^{\infty}\delta^s\ r_{w,t+s} \\
&- \sum_{i=1}^{p}\ \phi_i\ E_{t-1}\ \sum_{s=1}^{\infty}\delta^s\ d_{t-1+s} + \sum_{i=1}^{p}\ \phi_i E_{t-1}\ \ \sum_{s=1}^{\infty}\delta^s\ r_{w,t-1+s}\ + \beta\ w_t - \\
&\lambda\ \zeta_t + \lambda \sum_{i=1}^{p}\ \phi_i \zeta_{t-i} + \varepsilon_{4t}
\end{aligned} \tag{15}
$$

Chart 6 shows the behaviour of ζ_t for three representative household classes. Note that the net tax rate has always been positive during the sample period for landlords and negative. i.e. the net effect has been that of a subsidy, for owner-occupiers. For those who buy a house and decide to leave it unoccupied, the net tax rate is positive only since the late nineties. In all three cases, however, the estimated tax rates show an upward trend, although for landlords this trend does not start until the end of the nineties.

Table 4 shows the estimates of λ obtained from equation (14) and the three empirical versions of equation (15) for the representative landlord, where the quarterly net tax rate has been obtained by linearly interpolating the annual one. As can be seen, the coefficient estimates are small, non-significant and in one case even the sign is wrong.[9] Interestingly, if we made our computations including the non-significant point estimates for λ we would obtain roughly the same overvaluation at the end of the sample period (the estimated average would be around 28%) and also the same distance from the observed ratio to its estimated short-term adjustment path (around 2% on average). These results support the view that taxes are unlikely to have been a key determinant of the sharp increase in the ratio observed in the last few years.

9. These results do not change if the alternative net tax rates for the representative households who are first-home owner occupiers or second-home owners are considered instead.

4 Conclusions

House prices have increased markedly in Spain in recent years, adding to the strength of household consumption. Against this background, this paper has sought to assess whether current price levels are broadly consistent with their economic fundamentals.

In particular, we exploited the equilibrium relationship between prices and rents under different present-value models in order to assess the compatibility of Spanish house prices with fundamentals. The slow and differing adjustment dynamics of house prices and rents to changing conditions have also been taken into account. In particular, we adopted an approach that incorporates a non-instantaneous short-term adjustment of price-to-rent ratios to changes in their equilibrium conditions.

According to our estimates, there are a number of results which have proved fairly robust to the choice of the discount factor. In particular, part of the increase in the house price-to-rent ratio during the late nineties can be seen as a return to long-run equilibrium following a downwards overreaction of house prices after the previous peak of the late 1980s. Later on, however, marked increases in house prices took the price-to-rent ratio well above its long-run equilibrium level, although it remained in line with the short-term adjustment patterns which have historically characterised movements in this market. More specifically, by 2004 the price-to-rent ratio was between 24% and 32% above long-run equilibrium but only about 2% above the model forecasts which also take into account the short-run rigidities in this market that prevent observed ratios from instantaneously adjusting to changes in the long-run equilibrium. Finally we have also provided some evidence supporting the robustness of these results to the inclusion of taxes in the asset pricing relationships.

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Table 1. Descriptive statistics
Sample period 1987Q2-2004Q4

	Dlhp	Dlr	q	Dlc	Rm	R10y	Dly	Dlw	Rpd
Mean	0.0161	0.0043	4.8281	0.0077	0.0097	0.0874	0.0090	0.0188	0.0159
Median	0.0198	0.0030	4.7968	0.0081	0.0213	0.0870	0.0089	0.0187	0.0151
Maximum	0.0569	0.0272	5.2823	0.0282	0.3370	0.1090	0.0370	0.0596	0.0837
Minimum	-0.0684	-0.0196	4.5004	-0.0196	-0.3465	0.0662	-0.0173	-0.0463	-0.0466
Std. deviation	0.0234	0.0080	0.1792	0.0085	0.1358	0.0097	0.0097	0.0207	0.0244
Skewness	-0.5945	0.2641	0.5963	-0.3396	-0.4611	0.0115	-0.0519	-0.2764	0.0270
Kurtosis	3.8395	4.0139	2.7932	3.4698	3.3718	2.6683	3.6891	3.1330	2.9624
Jarque-Bera	6.3549	3.9211	4.3947	2.0458	2.9663	0.3316	1.4569	0.9698	0.0130
P-value	0.0417	0.1408	0.1111	0.3595	0.2269	0.8472	0.4827	0.6158	0.9935

Notes:

- Dlhp, Dlr, Dlc, Dly and Dlw stand for the first difference of the logs of house prices, rents, household consumption, GDP and household total net wealth, respectively. All them have been deflated by a CPI index excluding shelter.
- Rm, R10y and Rpd stand for the return on the Ibex-35 stock exchange index, the return on 10-year public debt, and the bond total return index, respectively. Returns have been deflated by a CPI index excluding shelter. R10y has been de-trended to guarantee stationarity.
- q stands for (log) ratio of house prices to rents.
- Jarque-Bera stands for the Jarque-Bera normality test whose p-value is shown in the row below.

Table 2. VAR estimates

Endogenous variables: rents, the discount factor, GDP, (net) financial and non-financial wealth and a 10-year interest rate and consumption, when they do not play the role of discount factor. All of them are in first differences (except returns) and in real terms.

Sample period: 1987Q2-2004Q4

	Discount factor							
	Consumption growth		Return on Ibex-35		Return on bond porfolio		Change in households' financial wealth	
	Rents	Disc. factor	Rents	Disc. factor	Rents	Disc. factor	Rents	Disc. factor
$\bar{R}^2$	0.49	0.23	0.46	0.13	0.46	0.30	0.47	0.10
σ	0.005	0.008	0.006	0.121	0.005	0.020	0.005	0.039
Q1	0.33 (0.57)	0.77 (0.38)	0.08 (0.78)	0.04 (0.85)	0.01 (0.91)	0.14 (0.71)	0.00 (0.95)	0.37 (0.54)
Q4	2.57 (0.63)	2.03 (0.73)	2.23 (0.69)	0.29 (0.99)	2.89 (0.58)	1.06 (0.90)	3.46 (0.48)	1.39 (0.85)
Q8	3.60 (0.89)	7.98 (0.44)	3.28 (0.92)	3.39 (0.91)	4.50 (0.81)	2.95 (0.94)	4.26 (0.83)	5.62 (0.69)

Notes:

- All VARs include four lags of the endogenous variables.
- Qi stands for the standard test on residual autocorrelation up to order i. P-values in brackets.

Table 3. GMM estimates
Sample period: 1987Q3-2004Q4

	Discount factor				
	Consumption growth	Return on Ibex-35	Return on bond portfolio	Change in households' financial wealth	Constant
Constant	0.96 (.12)	0.58 (.09)	0.27 (.34)	0.25 (.28)	-0.06 (.62)
τ	-14.7 (.09)	--	--	--	--
ρ	10.5 (.09)	--	--	--	--
ϕ	0.88 (.00)	0.88 (.00)	0.95 (.00)	0.95 (.00)	1.02 (.00)
β	2.76 (.05)	3.14 (.00)	1.75 (.00)	1.74 (.00)	0.16 (.65)
Sargan test	0.28 (.96)	.42 (.81)	2.52 (.28)	4.30 (.12)	14.1 (.00)
σ	0.119	0.119	0.062	0.063	0.031
Q1	2.67 (.10)	0.89 (.34)	0.64 (.42)	0.06 (.81)	5.19 (.02)
Q4	9.70 (.05)	3.88 (.42)	0.86 (.93)	1.13 (.89)	29.1 (.00)
Q8	13.8 (.09)	6.31 (.61)	4.38 (.82)	4.72 (.79)	44.7 (.00)
ARCH1	0.73 (.39)	0.31 (.58)	0.33 (.56)	0.09 (.77)	0.09 (.36)
ARCH4	3.55 (.47)	4.83 (.30)	2.33 (.68)	4.31 (.37)	8.15 (.08)
ARCH8	9.92 (.27)	11.1 (.19)	6.43 (.60)	5.95 (.65)	10.9 (.21)
Bera-Jarque	0.60 (.74)	0.10 (.95)	3.40 (.18)	0.65 (.72)	3.14 (.21)

Notes:
- Instruments: one lag of the variables involved. In the first column one lag of consumption growth, rent growth and 10-year de-trended interest rate has been added to overidentify parameters.
- P-values in brackets.
- w in columns 2 to 4 is the -(real log) rate of growth of households' financial wealth beyond its sample average.
- Qi stands for the standard test on residual autocorrelation up to order i.
- ARCHi stands for the standard test on residual ARCH-type heteroscedasticity up to order i.
- Bera-Jarque stands for the Bera-Jarque test on residual normality.

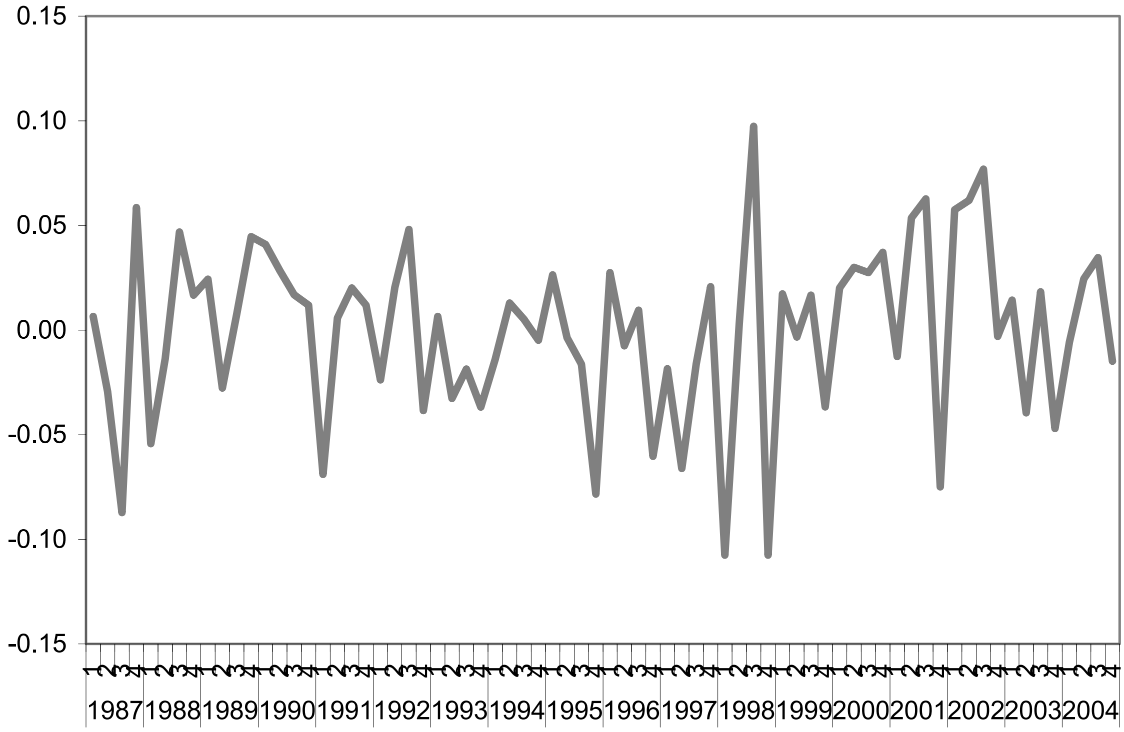
Table 4. GMM estimates of tax effects on the price-to-rent ratio
Sample period: 1987Q3-2004Q4

	Discount factor			
	Consumption growth	Return on Ibex-35	Return on bond porfolio	Change in households' financial wealth
λ	0.01	0.01	-0.00	0.00
(p-value)	(0.47)	(0.25)	(0.91)	(0.94)

Notes:
- Instruments: the same as in Table 3 plus the net tax rate at *t* and *t-1.*

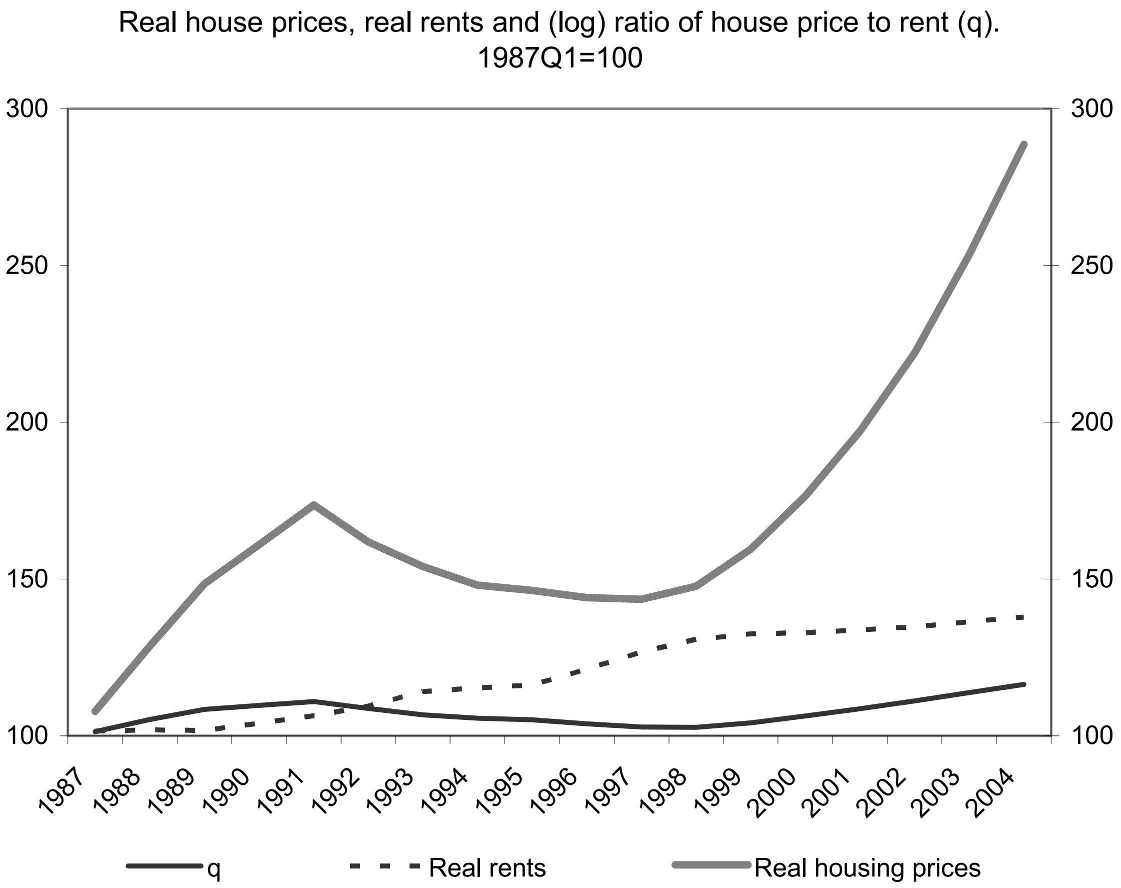
Chart 1

Transitory demand pressures in the housing market (a)



(a) De-meaned and sign-changed log quarterly changes in households' gross financial wealth.

Chart 2



Real house prices, real rents and (log) ratio of house price to rent (q).
1987Q1=100
300
250
200
150
100
300
250
200
150
100
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
q
Real rents
Real housing prices

Chart 3.1

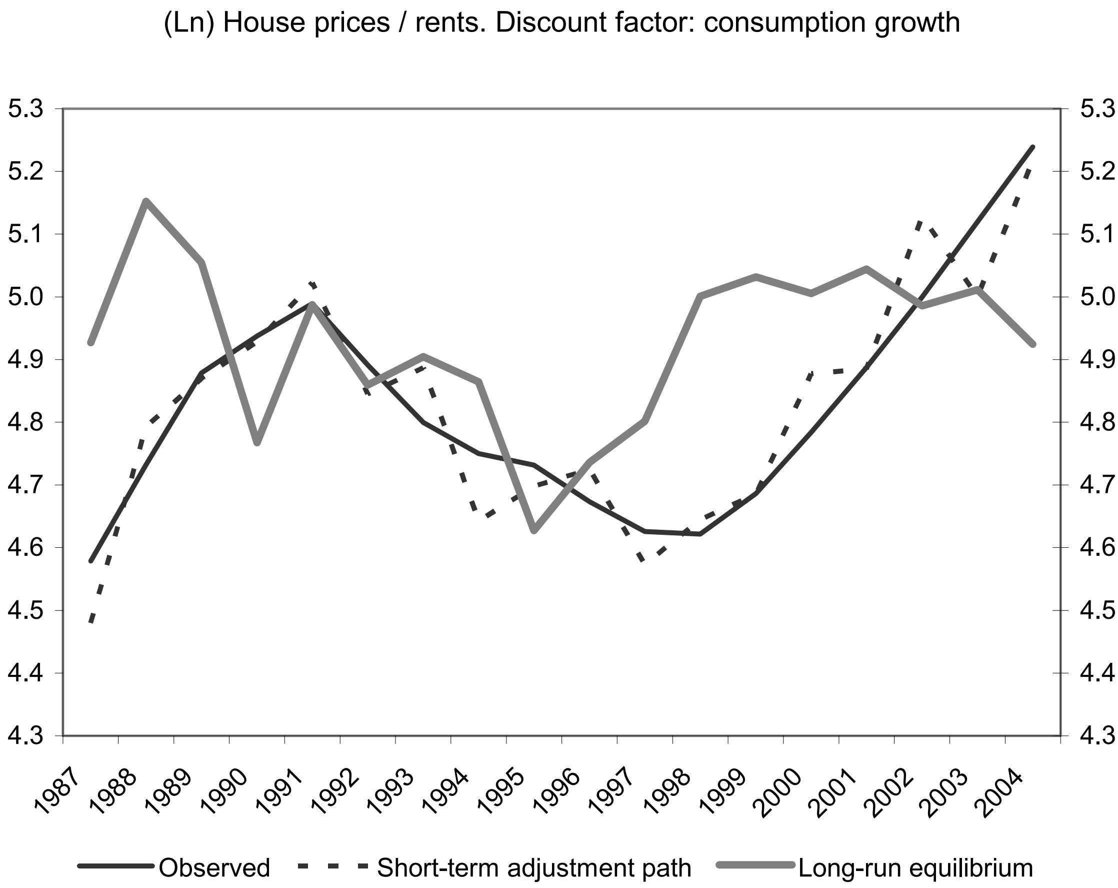

(Ln) House prices / rents. Discount factor: consumption growth
5.3
5.2
5.1
5.0
4.9
4.8
4.7
4.6
4.5
4.4
4.3
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
Observed
Short-term adjustment path
Long-run equilibrium

Chart 3.2

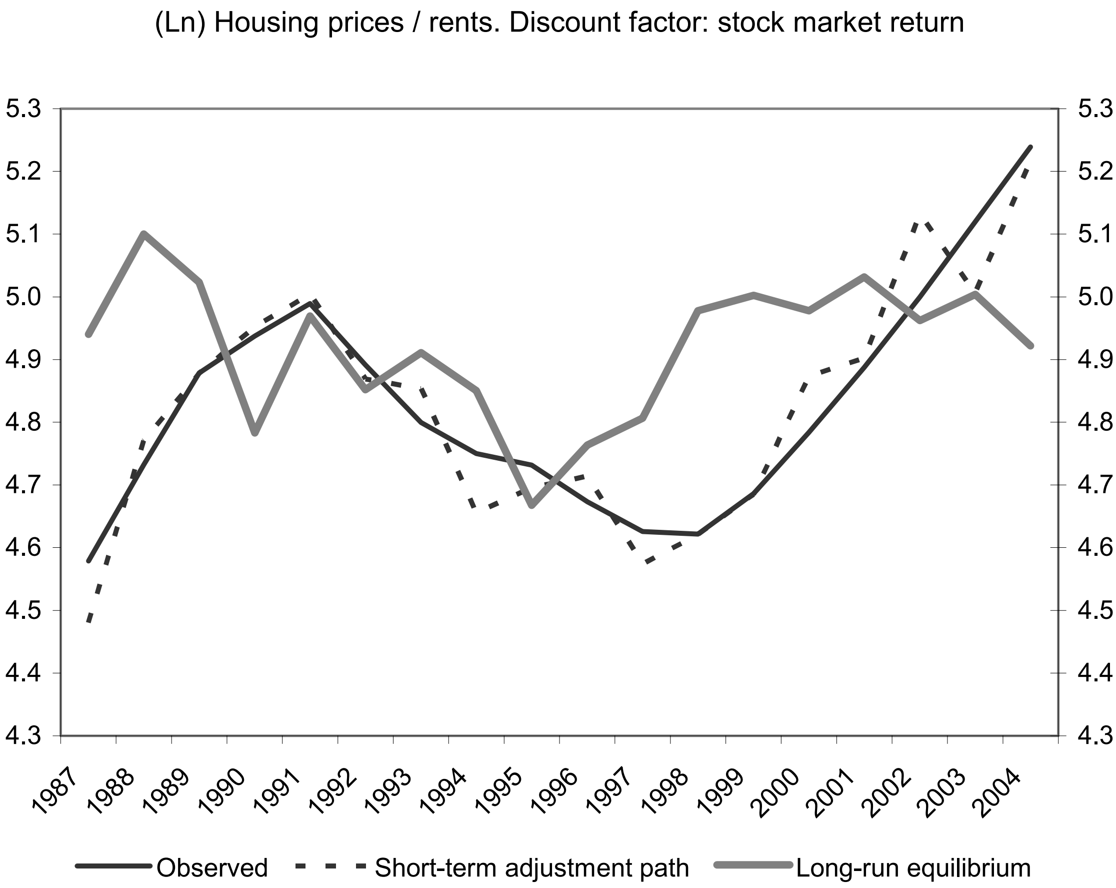

(Ln) Housing prices / rents. Discount factor: stock market return
5.3
5.2
5.1
5.0
4.9
4.8
4.7
4.6
4.5
4.4
4.3
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
Observed
Short-term adjustment path
Long-run equilibrium

Chart 3.3

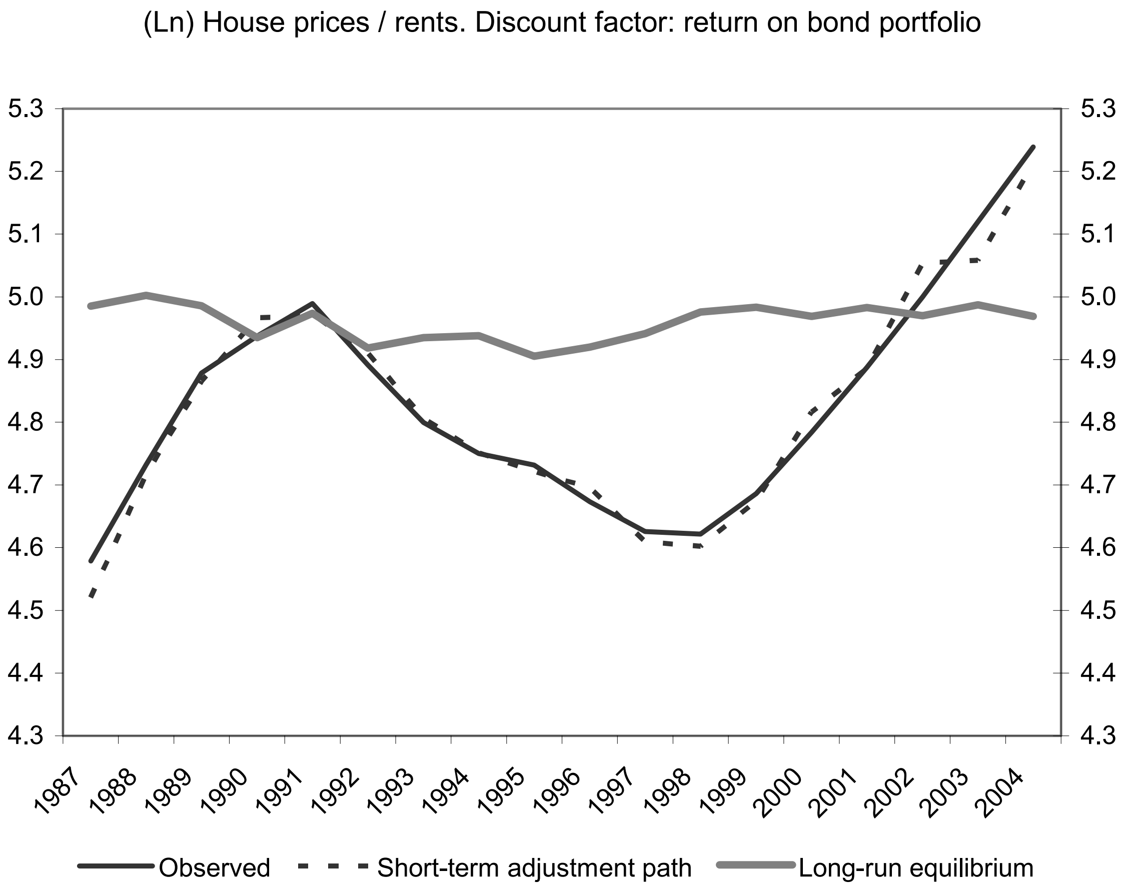
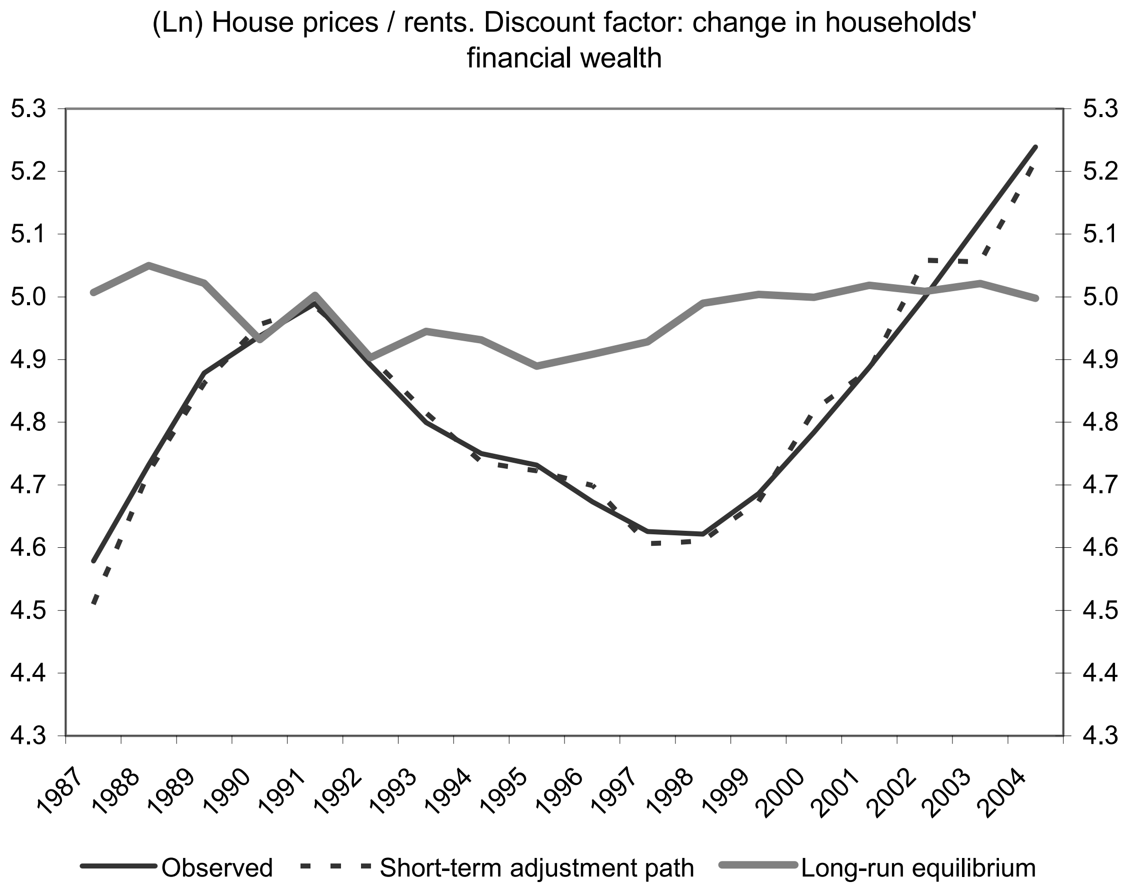

(Ln) House prices / rents. Discount factor: return on bond portfolio
5.3
5.2
5.1
5.0
4.9
4.8
4.7
4.6
4.5
4.4
4.3
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
Observed
Short-term adjustment path
Long-run equilibrium

Chart 3.4



(Ln) House prices / rents. Discount factor: change in households' financial wealth
5.3
5.2
5.1
5.0
4.9
4.8
4.7
4.6
4.5
4.4
4.3
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
Observed
Short-term adjustment path
Long-run equilibrium

Chart 4

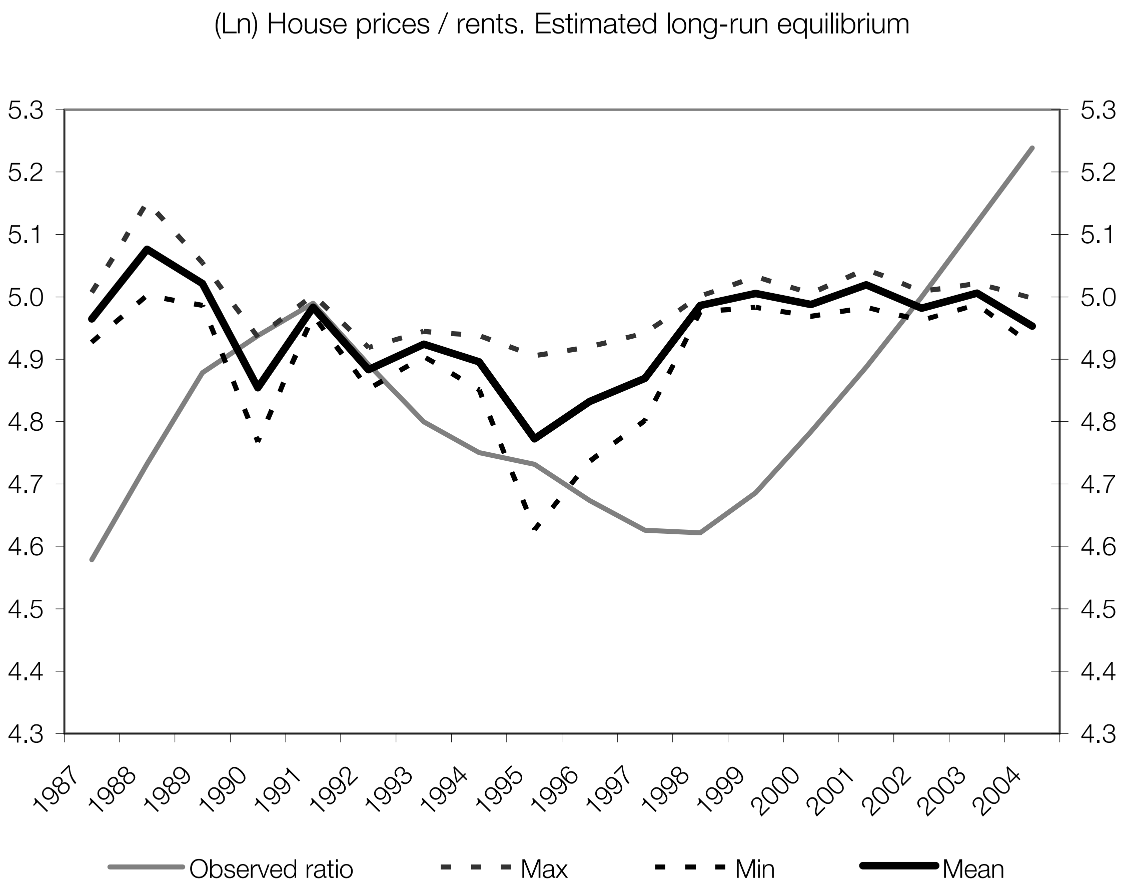
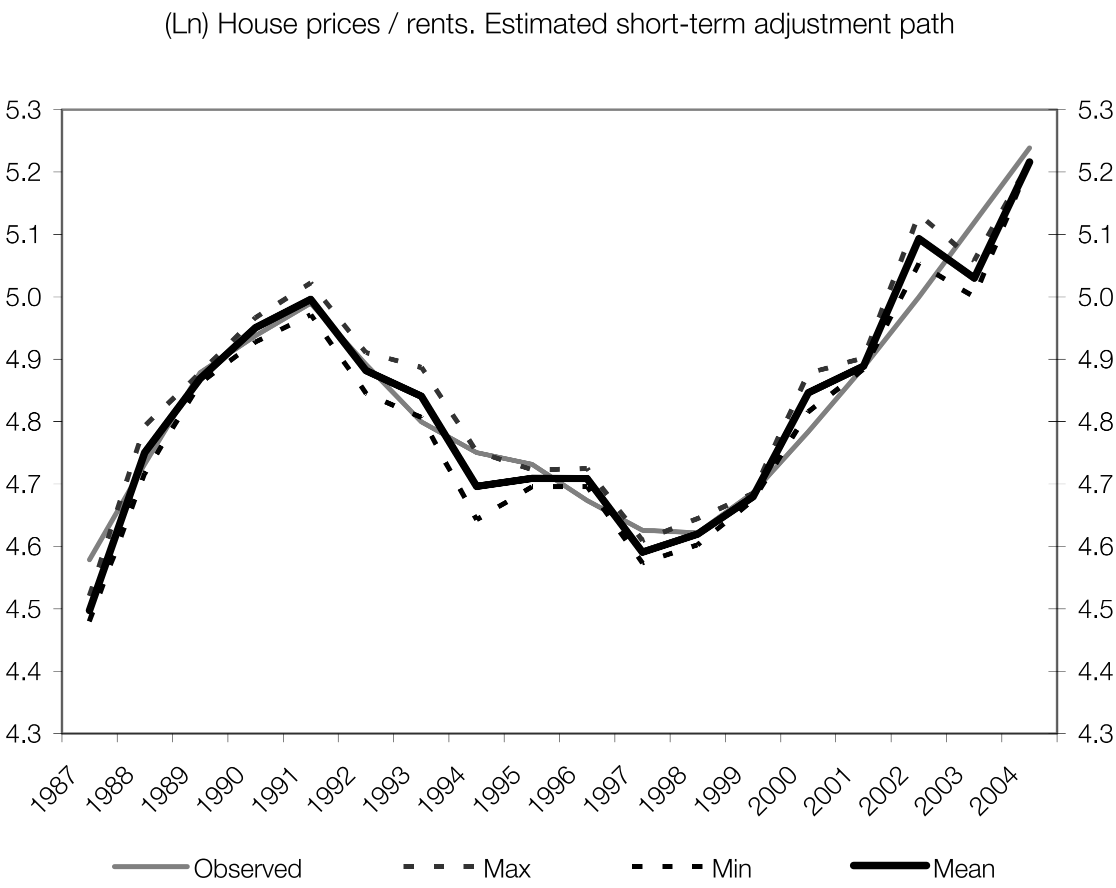
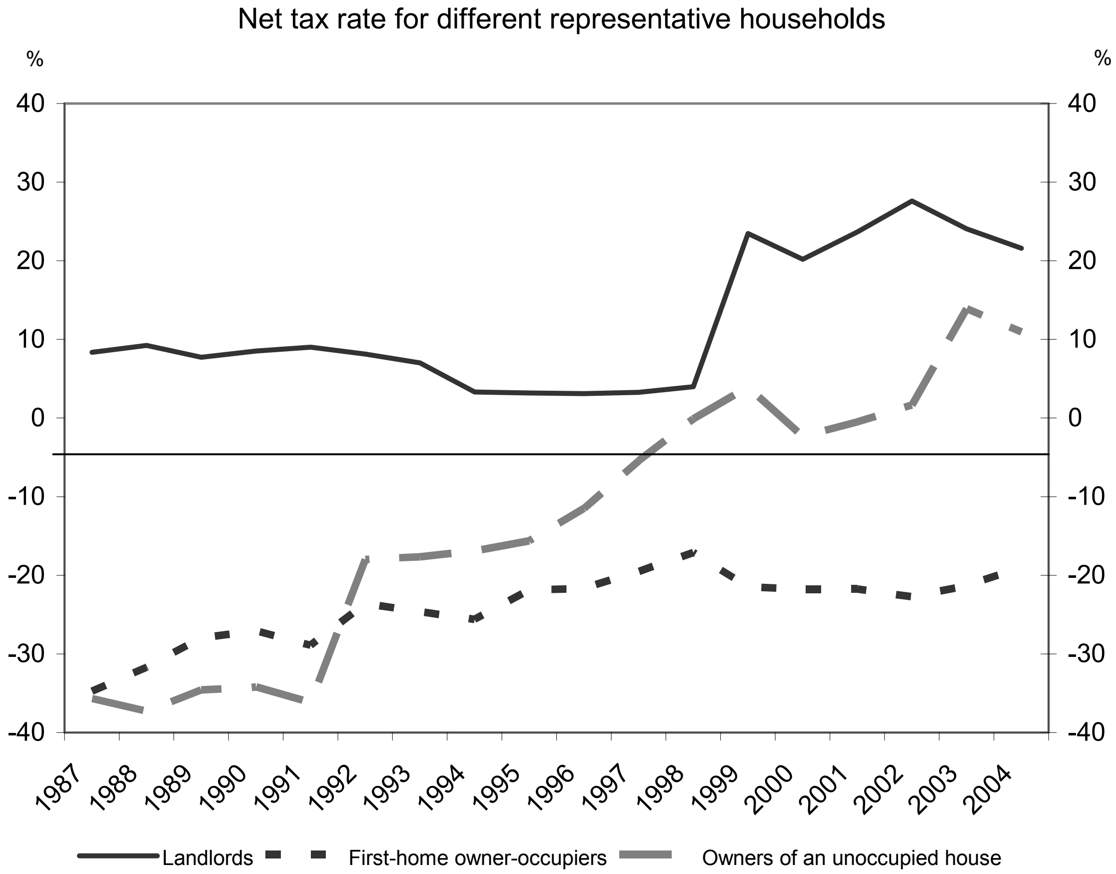

(Ln) House prices / rents. Estimated long-run equilibrium
5.3
5.2
5.1
5.0
4.9
4.8
4.7
4.6
4.5
4.4
4.3
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
Observed ratio
Max
Min
Mean

Chart 5



(Ln) House prices / rents. Estimated short-term adjustment path
5.3
5.2
5.1
5.0
4.9
4.8
4.7
4.6
4.5
4.4
4.3
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
Observed
Max
Min
Mean

Chart 6


Net tax rate for different representative households
%
%
40
30
20
10
0
-10
-20
-30
-40
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
Landlords
First-home owner-occupiers
Owners of an unoccupied house

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